How to cite: Santos PJ, Santos MS, Vasconcelos ABS, Da Silva-Grigoletto ME.High and low volume core stabilization training in chronic low back pain: randomized crossover study. Rev Bras Fisiol Exerc 2022;21(2):101-112. https://doi.org/10.33233/rbfex.v21i2.5102

RBFEx
ISSN Online: 2675-1372

Revista Brasileira de Fisiologia do Exercício

Original article

High and low volume core stabilization training in chronic low back pain: randomized crossover study

Alto e baixo volume do treino de estabilização do core na dor lombar crônica: ensaio randomizado cruzado

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ABSTRACT

Introduction: Core stabilization training is pointed as an effective option for pain relief chronic non-specific low back pain (CNLBP), however, the adequate training volume to induce analgesia is still unknown. **Objective:** To evaluate the effect of one session of high and low volume core stabilization training protocols on endogenous pain modulation in women with CNLBP. **Methods:** This is an evaluator-blinded randomized crossover trial. Eighteen volunteers participated of the study, whom performed two core stabilization training sessions: high and low training volume. The variables evaluated were the pressure pain thresholds (PPT) and temporal summation (TS) by digital pressure algometer, in addition to the conditioned pain modulation (CPM) using a pressure algometer and ischemic compression with sphygmomanometer as conditioned stimulus. A 2x2 repeated measures ANOVA was performed to compare training and time, Bonferroni's post hoc test for pairwise comparison from interactions (time and training). Data were expressed as mean ± standard deviation and the significance level established in 5%. **Results:** When comparing pre and post intragroup, low volume core stabilization training showed significant increase at the PPT in L5 (p<0.05) and tibialis anterior (p<0.01). High volume training not showed a significant increase in none of the PPT measures. However, none of the investigated protocols changed TS and CPM in women with CNLBP. **Conclusion:** Low volume core stabilization training produces local analgesia and remote hypoalgesia, demonstrated by increased PPT in L5 and tibialis anterior. However, none of the investigated protocols were effective to reduce the central sensitization assessed by CPM and TS.

Keywords: low back pain; physical exercise; analgesia; women.

RESUMO

Introdução: O treino de estabilização do core é indicado na literatura como opção eficaz na dor lombar crônica (DLC), no entanto, o volume adequado desse treinamento para induzir analgesia nessa população permanece desconhecido. **Objetivo:** Avaliar o efeito de uma sessão do treino de estabilização do core de alto e baixo volume na modulação endógena da dor em mulheres com DLC. **Metodologia:** Trata-se de um ensaio clínico, randomizado, cruzado e cego em relação ao avaliador. Dezoito voluntárias realizaram duas sessões do treinamento de estabilização do core: alto e baixo volume. Foi avaliado o limiar de dor por pressão (LDP), somação temporal (ST) e modulação condicionada da dor (MCD) antes a após a realização do treinamento. A ANOVA de medidas repetidas 2x2 foi realizada para comparar treino e tempo, o teste post hoc de Bonferroni para comparação em pares das interações (tempo e treinamento). Os dados foram expressos em média e desvio padrão e o nível de significância estabelecido em 5%. **Resultados:** O treino de estabilização do core de baixo volume apresentou aumento significativo do LDP em L5 (p<0,05) e tibial anterior (p<0,01). Já o treino de alto volume não apresentou aumento significativo no LDP. No entanto, nenhum dos protocolos investigados alteraram a ST e MCD em mulheres com DLC. **Conclusão:** O treino de estabilização do core de baixo volume produz analgesia local e hipoalgesia remota, no entanto, nenhum dos protocolos investigados foram capazes de reduzir a sensibilização central avaliada por meio da CPM e ST.

Palavras-chave: dor crônica; lombalgia; exercício físico; analgesia; mulheres.

Received: February 17,2022; Accepted: March 18, 2022.

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Introduction

Chronic low back pain (CLBP) can be classified as specific or non-specific, according to its origin. Chronic nonspecific low back pain (CNLBP) is not associated with a disease or attributable cause and represents the majority of cases, about 90% [1]. A comparative study show that patients with CLBP have greater pain sensitization when compared with healthy controls [2]. Despite not having a justifiable cause, studies show that central sensitization (CS) can contribute to the development and maintenance of CNLBP [3]. In the current scientific literature, the CS is commonly evaluated by means of the temporal summation (TS) [4].

Physical exercise is recommended as a treatment to CNLBP [5], since exercise activates endogenous analgesia pathways [6] of healthy people or patients with CNLBP [7]. Regarding healthy people, pain-free individuals, an acute exercise session results in a period of hypoalgesia known as exercise induced hypoalgesia (EIH) [8]. EIH is usually assessed by pressure pain thresholds (PPT) measured before and after an exercise session [9]. There is an increase in these thresholds during EIH period, which may last for up to 30 minutes after exercise [10]. In individuals with chronic pain, different results were found after an acute exercise session on pain sensitivity [11,12] which can be explained in part by the increase central excitability and decrease in the conditioned pain modulation (CPM) [13]. CPM is the traditional method to assess the activation of the endogenous descending inhibitory pathways and brain facilitators [14,15].

In this context, studies showed that physical exercises focused on improvement of the strength, motor control and endurance of the trunk muscles are more effective in reducing signs and symptoms and improving functional capacity of individuals with CNLBP when compared the cardiorespiratory exercises, global exercise and pilates [15,16]. Thus, evidence suggests that stabilization exercises have better results in reducing pain intensity and disability when compared with controls or other types of exercise [17,18].

A recent systematic review [19] showed that, in general, this training is performed with three sets, however, it is not clear if this training volume is the most adequate. In addition, is necessary estimate the minimum training dose for patients with CNLBP. Physical exercise can excite and inhibits the CNS, resulting in hyperalgesia or hypoalgesia, respectively [13], and the training volume is related to these effects. Thus, it is important to determine the necessary training volume to induce analgesia in women with CNLBP.

In this sense, this study is justified by the importance of evaluating the effects of core stability training volume in women with CNLBP, since the ideal training dose cannot be determined by the current published data [20,21]. Therefore, the objective of this study was to evaluate the effect of a high and low volume of a core stabilization training session on endogenous pain modulation of women with CNLBP. We hypothesized that low volume core stabilization training generates acti-

vation of endogenous analgesic pathways, resulting in increased PPT, activation of CPM and decreased TS in these patients. We believe that low volume training do not cause increased central sensitization, but the activation of endogenous descending inhibitory pathways.

Methods

This is an evaluator-blinded randomized clinical crossover trial carried in the Department of Physical Education of the Federal University of Sergipe. The study was registered in the Brazilian Registry of Clinical Trials-ReBEC No: RBR-6wy5y4t (https://ensaiosclinicos.gov.br/rg/RBR-6wy5y4t).

Participants

It were included 18 post-menopausal women with a clinical diagnosis of chronic nonspecific low back pain; aged between 45 and 59 years; with pain level greater than three on the numerical pain rating scale; body mass index (BMI <30); not having undergone spinal surgery; not exercising regularly; not perform physical therapy or other pain treatment; do not use analgesic, anti-inflammatory, opioid or immunosuppressive medication. The exclusion criteria were missing one of the test days; having some motor, psychiatric or cognitive impairment, hearing, visual or communication disorder that make impossible to perform the protocol. The patients were recruited from waiting list for attendance in the rehabilitation center of the University Hospital.

The trial protocol was approved by the Research Ethics Committee of the Federal University of Sergipe, Brazil under No. 4.884.045 (CAAE 28060319.3.0000.5546) and followed the principles of the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all participants.

Sample size

The sample calculation was performed using the G-Power program, version 3.1.9.4, based on the results of Paungmali [22]. For a power of 95% and an alpha of 0.05, considering two conditions and two times, the total sample suggested was 16 volunteers. Five more participants were added, resulting in a total of 21 participants.

Outcomes

An evaluator blinded to the interventions received the participants and evaluated them before and after the training protocols.

The primary outcome was the pain, measured through the pressure pain threshold (PPT), assessed using a digital pressure algometer with an area of 1 cm2 (*Sistema®, EMG, São José dos Campos, SP, Brazil*). The measurement was performed in two different body sites, in the paravertebral and anterior tibial muscles. In the lumbar region the PPT was evaluated bilaterally 5 cm lateral to the spinous proces-

ses of L3 and L5 [23,24] and in the tibialis anterior the measurement occurred in the right leg at 5 cm from tibial tuberosity [24-26]. With the algometer positioned perpendicular to the patient's tissue, increasing pressure was applied and the patient was instructed to report when the pressure was clearly painful. Three measurements were done and the mean was recorded. The PPT was evaluated by a physical therapist with clinical experience in the treatment of patients with chronic low back pain and master in physiological sciences.

The secondary outcome was central sensitization (CS) assessed through conditioned pain modulation (CPM) and temporal summation (ST). To assess CPM, first, PPT was measured on the right forearm, 7.5 cm from wrist line. Then the conditioned stimulus was applied, to this an ischemic compression of 270 mmHg was performed on the contralateral arm with a sphygmomanometer (Mikatos®, Embu, SP, Brazil) positioned 3 cm close the cubital fossa. Pain intensity was verbally requested using the numerical classification pain scale and when equal or greater than 4, the PPT was measured in the right forearm, 7.5 cm from wrist line, during ischemic compression. Five minutes after this procedure, the PPT was measured again, now without compression [27].

TS was assessed with the algometer positioned 7.5 cm above the wrist line, exerting a constant pressure of 4 kg/cm2. The volunteer was asked to verbally inform the pain intensity through the 11-point numerical pain classification scale that ranges from 0 to 10, with 0 indicating no pain and 10 worst pain imaginable [28], during the 1º, 10º, 20º and 30º seconds of stimulation [27].

Factors as medication use, sleep, kinesiophobia, and depression can influence perception and sensory testing. To control these factors, the participants were instructed not to use medication 24 hours before the tests performed and questionnaires were applied to assess the quality of sleep, kinesiophobia and the level of depression of the volunteers.

Randomization

Randomization was performed using a Latin square design, the treatments were distributed so that each one appeared only once in each line [29]. In the first session, the volunteer performed the corresponding training protocol and 48 hours after finish the first protocol, the volunteer returned to the laboratory to the second training, completing the crossover.

Intervention

All participants performed the interventions in a temperature-controlled environment (23 ± 0.5°C), always during the morning, with 48 hours between sessions to minimize any possible transmission effects between workouts [20,22]. The training protocols were conducted by a physical education professional with master's degree in physical education and years of experience in the realization training protocol. All protocols were performed by the same evaluator.

Before starting training, the volunteers were instructed on the breath they have maintain during the protocols, for this, performed five hollowing maneuvers, three sets of five bracing breaths, then, to prepare the muscles for the exercises, thoracic, lumbar and hip mobility was performed, five sets each.

The training protocols consisted of two moments: in the first, exercises were performed to maximum muscle strength and motor control, for this, were performed the hunting dog exercises, lateral plank with support on both feet, bilateral pelvic lifting, lateral plank with support of one foot, superman static and front plank. In the second moment, the exercises had as objective to train the resistance of this musculature, through the abdominal curl up, abdominal oblique and hip flexion (in dorsal decubitus and knee flexion), carried out in this order. The density of the exercises was 1:2 for both training, with 20 seconds of exercise and 40 seconds of rest. The number of sets was 3 for high and 1 for low, considering the same exercises. Moreover, there was no rest between exercises and all were performed in isometric.

The sequence of the high and low volume core stability training exercises can be viewed in board 1.

Chart 1 - Description of core stability training

<table>
<tr><th colspan="3"></th><th>Low volume</th><th>High volume</th></tr>
<tr><td rowspan="5">Pre training</td><td colspan="2">Hollowing breathing maneuver</td><td>5 repetitions</td><td>5 repetitions</td></tr>
<tr><td colspan="2">Bracing type breathing maneuver</td><td>3 sets of 5 repetitions</td><td>3 sets of 5 repetitions</td></tr>
<tr><td colspan="2">Thoracic mobility</td><td rowspan="3">5 sets</td><td rowspan="3">5 sets</td></tr>
<tr><td colspan="2">Lumbar mobility</td></tr>
<tr><td colspan="2">Hip mobility</td></tr>
<tr><td rowspan="10">Exercices</td><td rowspan="6">First moment</td><td>Bird-dog</td><td rowspan="10">1 set sustained for 20 seconds with 40 seconds of rest</td><td rowspan="10">3 sets sustained for 20 seconds with 40 seconds of rest</td></tr>
<tr><td>Side plank with support on both feet</td></tr>
<tr><td>Bilateral pelvic lifting</td></tr>
<tr><td>Side plank with one foot support</td></tr>
<tr><td>Static Superman</td></tr>
<tr><td>Front board</td></tr>
<tr><td rowspan="4">Second moment</td><td>curl up</td></tr>
<tr><td>Abdominal Oblique</td></tr>
<tr><td>Hip bending</td></tr>
</table>

Results

This trial was carried between October 2019 and February 2020. 75 potential participants were selected and/or evaluated, of which 21 were selected to be part of the study. 18 participants (52.72 ± 3.40 years) were included in the study, all vo-

lunteers performed two types of protocols, low volume core stabilization training and high volume core stabilization training. The flow diagram of the enrollment, randomization, training, and data analysis process can be visualized in figure 1. The personal characteristics of the sample can be visualized in table I.

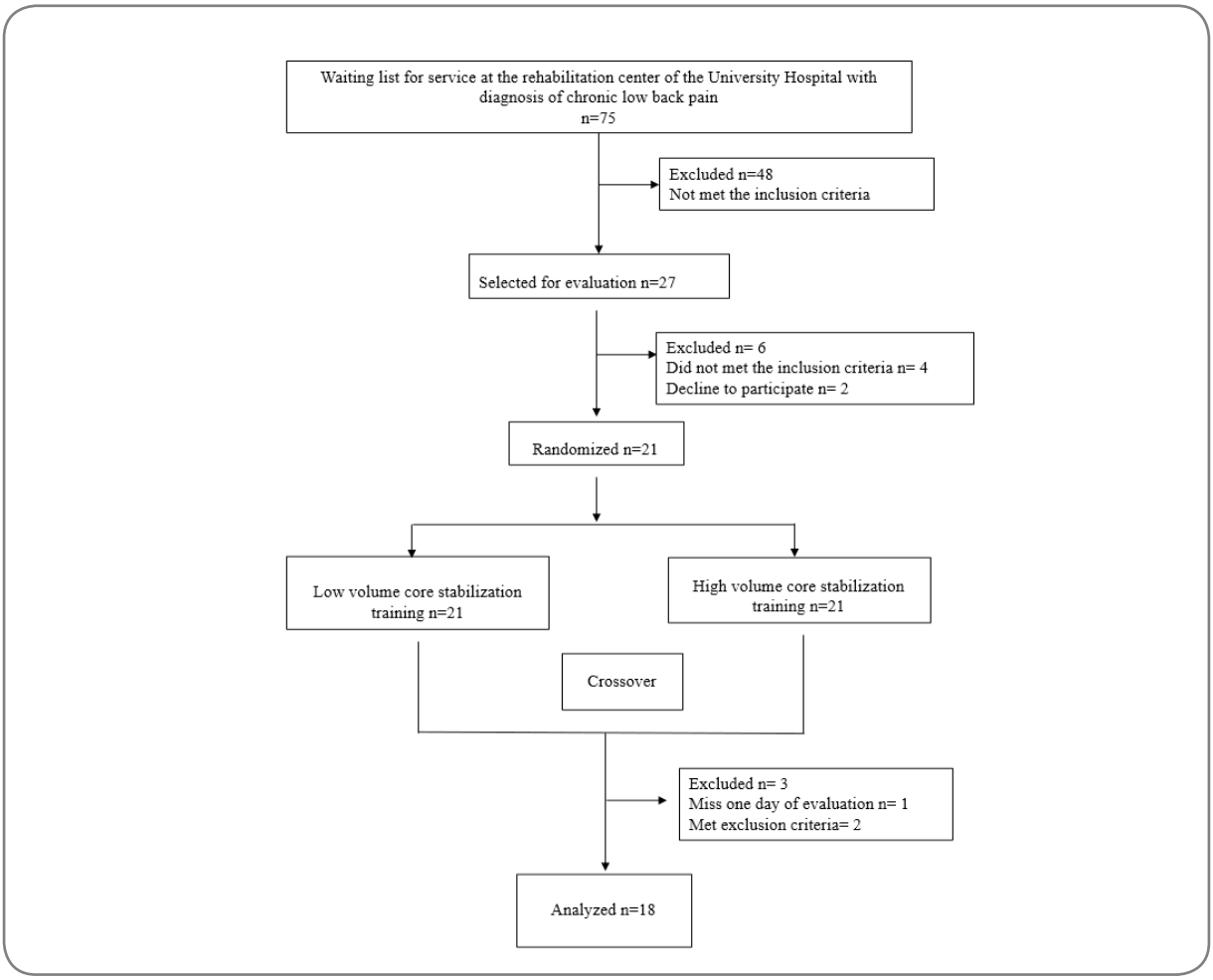


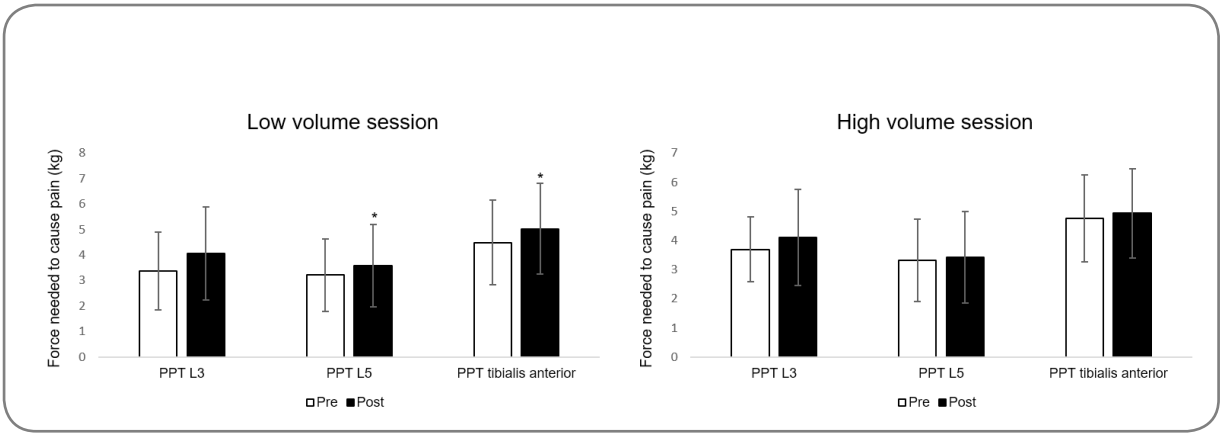
Figure 1 - Flow diagram of the randomized crossover trial

Table I - Personal characteristics of the sample

Characteristics	Mean ± SD
Age (years)	52.72 ± 3.40
Weight (kg)	74.53 ± 15.31
Height (cm)	1.60 ± 0.06
BMI (kg/m²)	29.00 ± 5.30
Pain intensity (cm)	7.25 ± 3.24

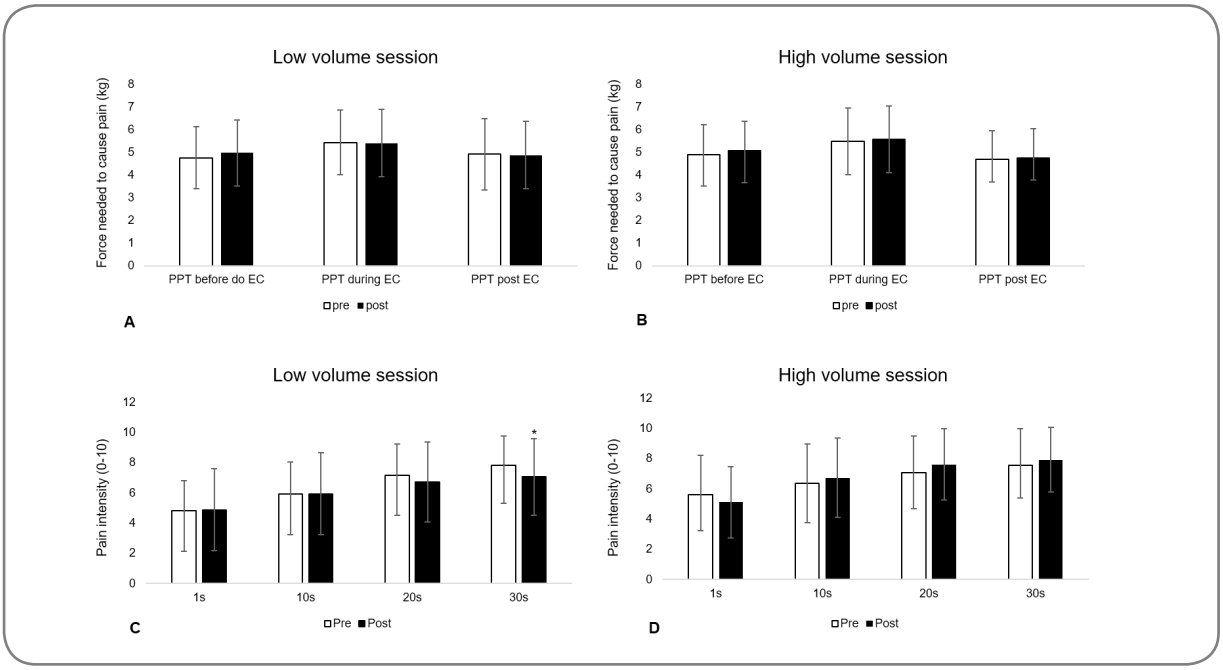
BMI = Body Mass Index

When compared the pre and post intragroups, the low volume core stabilization training significantly increased the PPT in L5 (3.21 ± 1.42 pre; 3.58 ± 1.61 post; $p<0.05$) and tibialis anterior (4.49 ± 1.67 pre; 4.97 ± 1.45 post; $p<0.01$). High-volume training did not increase none of the PPT measures. No differences were noted when compared the PPT between low and high volume groups. These results of low and high volume core training in the PPTs can be seen in Figure 2.



*Significant intragroup difference (p < 0.05); PPT = pressure pain threshold; L3 = third lumbar vertebra; L5 = fifth lumbar vertebra
Figure 2 - Difference between the means of pre and post training results in the PPT

The intragroup comparison showed not significant difference in the TS in high volume training, however, low-volume training showed a significant difference for the 30ºs measure (7,83 ± 1,94 pre; 7,05 ± 2,53 post; p<0,05). In the CPM analysis, the intragroup comparison showed not significant difference from pre to post in none of the protocols investigated. When comparing the effect of low volume with high volume training not significant difference for none intervention in the CPM and TS. The results of the low and high volume core stabilization training in the TS and CPM can be seen in Figure 3.



A and B) Conditioned pain modulation; C and D) Temporal summation of pain; *Significant intragroup difference (p < 0.05). PPT: pressure pain threshold; EC = conditioned stimulus; S = seconds
Figure 3 - Difference between the means of pre and post training results in the CPM and ST

Patients were recruited from the waiting list of a rehabilitation center, which contained only: name, sex, age, health problem that made him seek the physical therapy service and contact number. Thus, only a few criteria could be evaluated at this

first moment. After this survey, an evaluation was scheduled with everyone who met the inclusion criteria. After this evaluation, 4 people were excluded from the sample because they had a BMI > 30, had undergone spinal surgery and were undergoing physical therapy.

Discussion

Our study showed that low-volume core stabilization training decreased PPT in L5 and tibialis anterior muscle. Thus, the proposed training protocol caused an EIH in the injury site and remote hypoalgesia. However, the training protocol was not able to decrease CS and activate descending inhibitory pathways of women with CNLBP.

The mechanisms responsible for EIH are not fully understood. Human research shows controversial results [8], while animal studies showed that opioid hypothesis is more consistent. However, EIH can also occur through activation of the endocannabinoid, serotoninergic, immune, autonomic nervous system, and conditioned pain modulation systems [8, 10,13,30]. In populations with chronic pain, this phenomenon may be impaired in some people, and may remain unchanged or even have hyperalgesia in response to exercise. The mechanisms that can explain this fact are unknown [10].

Depending on the dose applied, physical exercise can either excite or inhibit the CNS, resulting in hyperalgesia or hypoalgesia [13]. The study by Dailey et al. [31] showed that patients with fibromyalgia report greater increases in pain and perceived fatigue after performing a physically strenuous task when compared to healthy individuals. Furthermore, a recent systematic review showed that a training duration of 20 to 30 minutes had a greater impact on effect sizes on pain and disability [19]. As evidenced in the studies above, patients with chronic pain benefit from a protocol of less fatiguing training for pain reduction, perhaps, that's why low volume training showed better results compared to high volume.

Studies have also shown increased excitability in the central nervous system in people with CKD and in other chronic pain conditions [26,32] these patients when undergoing an acute exercise session do not show EIH and in some cases even show hyperalgesia in response to training [33]. As observed in the present study, high volume showed no difference in reducing pain after performing training. This may be explained in part by the fact that this training generates a very large stimulus and excites the CNS even more.

Pain reduction post core stability training could be due the improved motor control, since when have good local motor control, it is possible to control the peripheral nociceptive impulse in progress and, eventually, central sensitization can be avoided [22]. However, as showed here, a single session of this training was not able to reduce central sensitization assessed through TS and CPM. Similar results were already found [34] and, in some cases, showing increased neuronal excitability after exercise [35].

One of the factors that probably influenced our results was the age and gender of the patients evaluated. The current literature shows that CPM is reduced with age and is more impaired in women with chronic pain conditions [36]. In human research, women have shown greater central excitability in measures as temporal summation, secondary hyperalgesia, referred pain, and decreased CPM [33,37,38]. These gender differences may, in part, explain impaired EIH in the chronic pain population. However, studies do not provide evidence that EIH is less effective in women [10].

To the best of our knowledge, this was the first study to evaluate the effects of core stability training in the endogenous pain modulation of women with CNLBP. The present research also investigated the influence of training volume in this population. To avoid hormonal interference, our study included postmenopausal women. In addition, majority research that evaluated EIH was conducted with young or healthy population, and those that evaluated PPT in individuals with chronic low back pain not present the PPT values of each investigated point separately [23,24,26]. The anatomical and biomechanical characteristics between the lumbar vertebrae may interfere the final results of the PPT evaluated. Therefore, values for each point should be presented separately. Furthermore, the studies that investigated core stabilization training not provide information about the training volume [19]. Future research should explore the effects of this long-term training in the endogenous pain modulation in this population.

Nevertheless, the study proposal to assess the volume of core stability training in women with CNLBP has important theoretical and clinical implications. Thus, is suggested that professionals that choose to use this method for treating patients with CNLBP, consider all of the above points before implementing the study results in the clinical practice. At the same time, our study indicated that the proposed training not increase pain perception, unlike studies that investigated the effects of physical exercise in other populations with chronic pain. Both training protocols are safe to be tested longitudinally, since they do not increase the pain threshold, however, the effects for pain reduction should be tested in the long term, comparing with other types of treatment suggested for chronic low back pain and a control group. Furthermore, this research can help professional in the clinical practice and researchers understand the neurophysiological process behind the training investigated in women with CNLBP.

Conclusion

Low volume core stabilization training produces local analgesia and secondary hypoalgesia, demonstrated by the increase in the PPTs of L5 and anterior tibialis. However, none of the treatment protocols were able to activate endogenous descending inhibitory pathways and decrease central sensitization. Further studies should investigate the long-term effects of the volume of this training.

Conflict of interest
None

Financing source
Santos PJ - Master's scholarship holder from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior-CAPES, Brazil (Process number: 88882.443503/2019-01).

Authors' contribution
Research conception and design: Santos PJ, Santos MS, Da Silva-Grigoletto ME; **Data collection:** Santos PJ, Santos MS; **Statistical analysis**: Santos PJ, Santos MS; **Data analysis and interpretation:** Santos PJ, Santos MS; **Writing of the document:** Santos PJ, Santos MS, Vasconcelos ABS; **Critical review of the manuscript for important intellectual content:** Vasconcelos ABS, Da Silva-Grigoletto ME.

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